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ABSTRACT

Students use aerial photographs in this investigation as they study erosion and deposition along a section of Lake Erie's coast and learn about how groins affect these processes. The teacher's guide presents an overview of the unit, a materials list, suggested instructional approaches, answers to discussion questions, and evaluation items. A student manual is also included. (WB)

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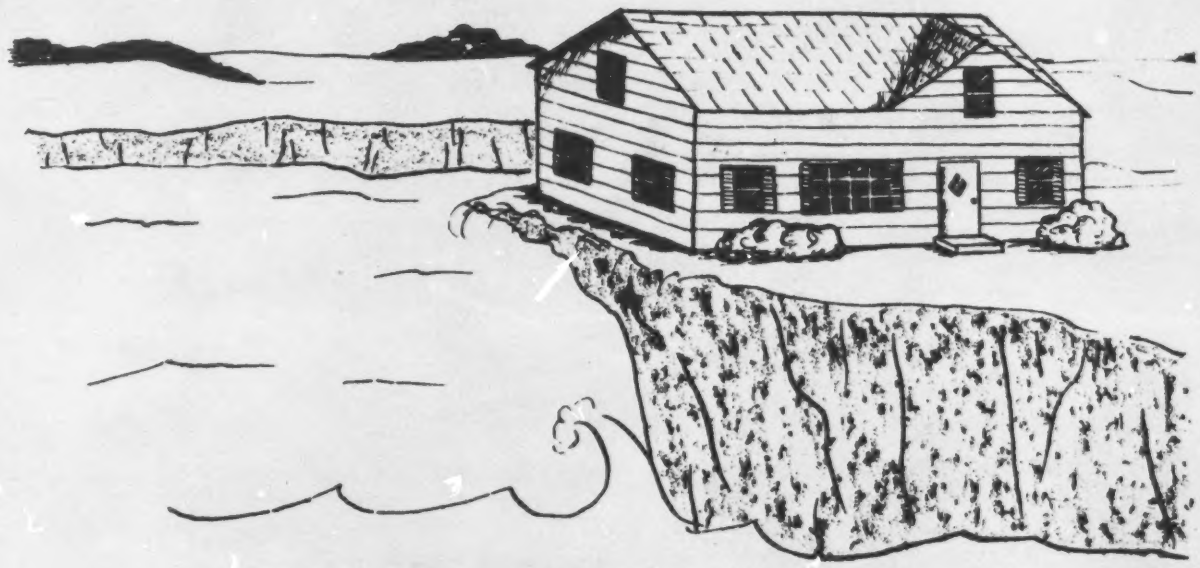
Ohio Sea Grant

OEAGLS - Oceanic Education Activities for Great Lakes Schools

EROSION ALONG LAKE ERIE

by

Beth A. Kennedy, Newark Public Schools
and
Victor J. Mayer, The Ohio State University



Ohio Sea Grant Program
Charles E. Herdendorf, Program Director
Victor J. Mayer, Principal Investigator

SE 035 141

OEAGLS INVESTIGATION 6

Completed April, 1979

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EROSION ALONG LAKE ERIE

INTRODUCTION

Shoreline and bluff erosion were identified in a 1976 survey of shoreline residents as one of the most critical problems along Lake Erie. Land losses of up to ten feet per year were estimated. Property damage totaled millions of dollars. Land loss and property damage are caused by the conflict between natural forces and human activity along the shoreline.

Ohio's Lake Erie shoreline consists of wetlands, low bluffs, and gently sloping shores in the western one-third of the state and glacial till and soft shale bluffs in the eastern two-thirds of the state. The rate of shore erosion is affected by the kind of land and rock materials and the use of protective structures.

OBJECTIVES

When you have completed this investigation, you should be able to:

1. Recognize some shoreline features on air photos.
2. Use air photos to;
    a. Determine how much shoreline has eroded away in a given area.
    b. Estimate an average rate of recession for a section of shoreline.
3. Calculate the amount of material eroded from a portion of shoreline.
4. Predict the effect of groins on a shoreline.

ACTIVITY A HOW FAST CAN A SHORELINE CHANGE?

MATERIALS

Ruler, tracing paper, pencil, paper clips, aerial photos of Painesville Township Park, and colored pencils.

PROCEDURE

In this activity you will be studying a portion of the Lake Erie shoreline in Lake County, Ohio. You will determine how fast erosion has occurred in the area and how much sand and clay has been removed by the waves and currents of the lake. You will be using photographs taken by an airplane flying over the area at two different times, once in 1954 and again 19 years later in 1973. Both photos represent the same area of the shoreline. When using the photos, be sure that the large area of water (Lake Erie) is at the top of the photo. Then it will be oriented just like a map. The top will be north; the left side of the photo, west; and the right side, east.

1. Examine the 1954 photo. Describe the shoreline.

_____

_____

_____

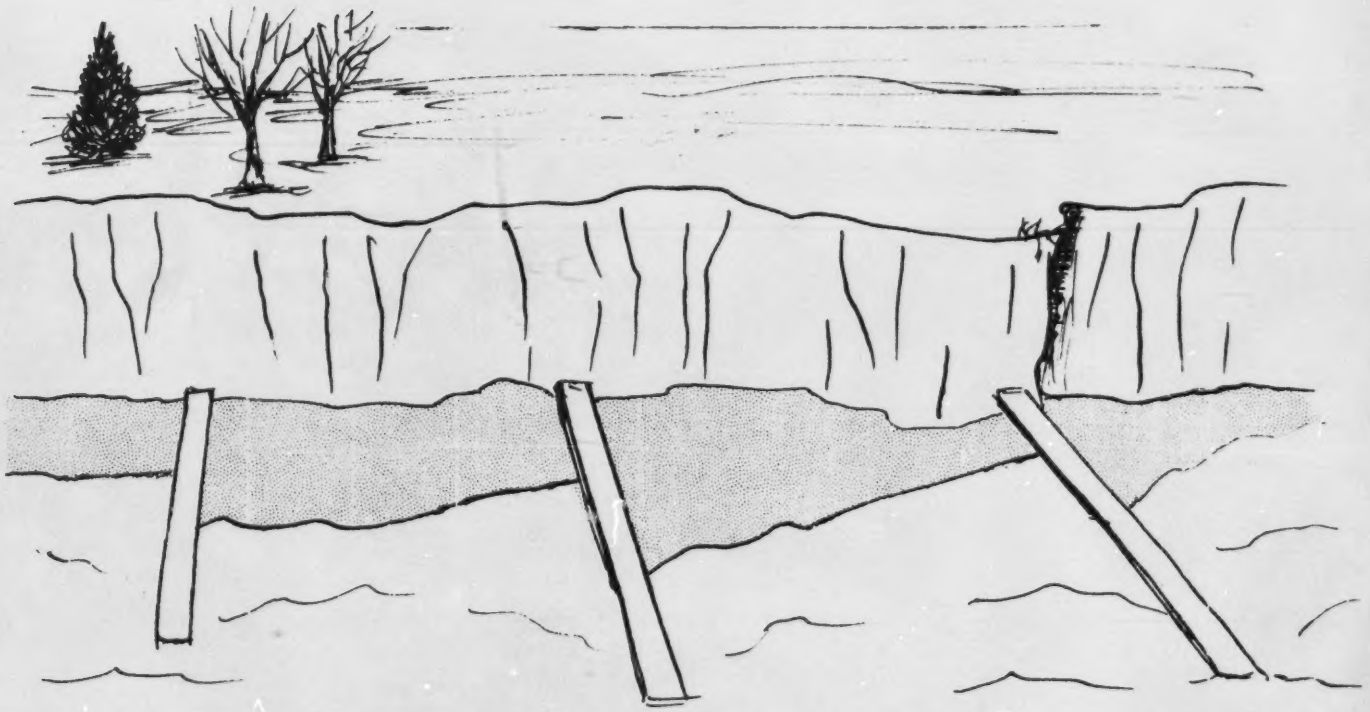
2. Now examine the 1973 photo. How has the shoreline changed?

_____

_____

What features have been destroyed?

_____



You should have noticed some straight objects jutting out into the water in the west central part of the photos. These are groins. They are structures designed to protect the shoreline by trapping sand.

3. How many groins are there in the 1954 photo?_____

   The 1973 photo?_____

4. Cover the 1954 photo with a sheet of tracing paper and secure it with paper clips.

5. Starting one inch in from the left border of the photo, draw 8 parallel N-S lines at one inch intervals. Label the lines A through H starting at the left line.

6. Using a pencil, trace the base of the bluff on the paper. Label this line "1954."

7. Now draw in and label the groins.

8. Outline several major road intersections. These will help you to position the paper on the other photo.

9. Now place the tracing paper on the 1973 photo. Match the road intersections.

10. Using a different colored pencil, trace in the base of the bluff. Label this line "1973." Draw in and label the groins.

11. Notice that you have two different shorelines. Lightly shade in the area between the two shorelines.

12. Why are there two different shorelines?

    _____

13. What does the shaded area between the two shorelines represent?

    _____

14. What differences do you note between the area of shoreline east of the groins and that to the west of the groins?

    _____

15. What caused these differences?

    _____

Between 1954 and 1973 a portion of the shoreline eroded away. Shore erosion occurs through the combined effects of waves and currents. Waves, especially during storms, will attack the bluffs along the shore causing them to collapse. Currents moving along the shore will pick up the sediments and carry them away. These currents flow in a predominant direction. Any obstruction will trap the sediment carried by the currents on its upcurrent side (the side from which the current is coming). On the down-current side of the obstruction, the currents will pick up a new load of sediment. Because of these processes the groins slow down erosion upstream and cause additional erosion downstream.

16. In what direction do the currents along this section of the shore move?

ACTIVITY B HOW MUCH LAND HAS BEEN LOST?

MATERIALS The map traced from the photos in Activity A, graph paper (10 squares per inch), and the topographic map of Perry, Ohio.

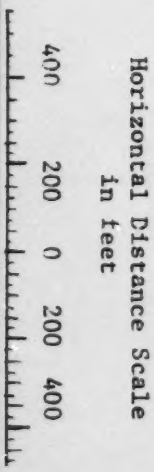
PROCEDURE In this part of the investigation you will actually calculate the amount of land that has been lost to erosion and the volume of material that made up that land.

1. Use your map of the two shorelines (Activity A). With the scale at the left edge of this page measure the distance between the two shorelines along each of the lines A through H. Enter your measurements in line Q of the worksheet on page 8.

2. Lines A through D are west of the groins. Average the distances for these four lines and enter them in line R. Now determine the average distance between shorelines for the other four lines and enter it in the worksheet.

You are now ready to determine the recession rate for this section of shoreline. The recession rate is the average distance the shoreline has been eroded away per year.

3. Divide each average distance in line R by 19 years, the length of time between the taking of the two photos. Enter in line S.



4. Which part of the shoreline, western or eastern, has a higher recession rate?

_____

Describe what this means.

_____

Where would you prefer to own shoreline property?

_____

5. Place your map over the piece of graph paper provided by your teacher. Locate the eastern most of the two prominent groins appearing on the 1973 photo. Count the number of squares in the shaded area to the east of the groin and enter in line T. Also count the number of squares to the west of the groin and enter on line T.

6. Each square represents 160 square feet of surface area. Calculate the total surface area eroded away and enter in line U.

To determine the total volume of material removed you will need to know its depth as well as its surface area. The depth of material will be roughly equivalent to the average height of the bluffs. To determine this, you will need a copy of the Perry, Ohio quadrangle.

7. Locate Painesville-on-the-lake. This is the same area represented on the air photos. Note that the contour lines are closely spaced along the shore at Painesville-on-the-lake. They represent the bluffs. The highest close-spaced contour represents the top of the bluff.

8. Determine the elevation of the lake._____

9. Determine the elevation of the bluff just <u>west</u> of Hardy road._____Subtract the elevation of the lake from that of the bluff and enter the difference on line V of the worksheet.

10. Now determine the elevation of the bluff to the <u>east</u> of Hardy road._____Subtract the elevation of the lake and enter the difference on line V.

11. Calculate the total volume of material removed by erosion by multiplying the average height of the bluffs times the total surface area removed. Enter in line W.

12. Determine the average yearly loss of material by dividing the total volume removed by 19 years. Enter on line X.

CONCLUSION

From this investigation, you have learned that a portion of the Lake Erie shoreline is retreating southward at a fairly rapid rate. It may surprise you to find out that this is occurring throughout the lake. The rate of recession will vary according to the hardness of the materials. Near Marblehead, for example, the rate is barely noticeable. Marblehead has limestone exposed in the bluffs along the lake. The shoreline on the northern side of the lake is retreating at a more rapid rate than in the Perry area, but northward. In a sense then, Lake Erie is getting bigger. What happens to all the material that is eroded? It eventually ends up filling in the deeper basins of the lake.

Lake shorelines are not the only shores that erode. The seacoast also erodes. The same processes, wind and currents, are involved, and the same protective structures are used. As you have seen, groins are effective in treating some local problems on a temporary basis. Although they do not offer a permanent solution to erosion problems, they may provide the extra time needed for other measures to be taken.

The following paragraph from Willard Bascom's *Waves and Beaches* describes how groins may be helpful in preventing sea-coast erosion.

> There is an instance in which a ship saved a lighthouse, instead of vice-versa. In 1883 the Cape Henlopen light on the Delaware coast was in imminent danger of being undermined by the sea. The high-water mark reached around the base and various emergency protective actions were being considered. Then in a storm the *Minnie Hunter* was driven ashore, grounding about five hundred feet north of the lighthouse. The wrecked ship immediately acted as a groin which dammed the coastal flow of sand and replaced the beach in front of the light so that the structure survived for many more years.

REVIEW QUESTIONS

1. Describe how you would determine the recession rate of a section of the Atlantic coast.

_____

_____

2. How would you determine the amount of material removed from a section of the Atlantic coast?

_____

_____

3. Describe what is likely to happen when a groin is built along a section of shoreline.

_____

_____

_____

WORKSHEET

	LINE	WEST A	WEST B	WEST C	WEST D	EAST E	EAST F	EAST G	EAST H
Q	Distance		+	+	+ =		+	+	+ =
R	Average Distance Q ÷ 4								
S	Recession Rate R ÷ 19 yr								
T	Squares								
U	Surface area T x 160 sq ft								
V	Cliff height								
W	Volume U x V								
X	Yearly loss W ÷ 19 yr								

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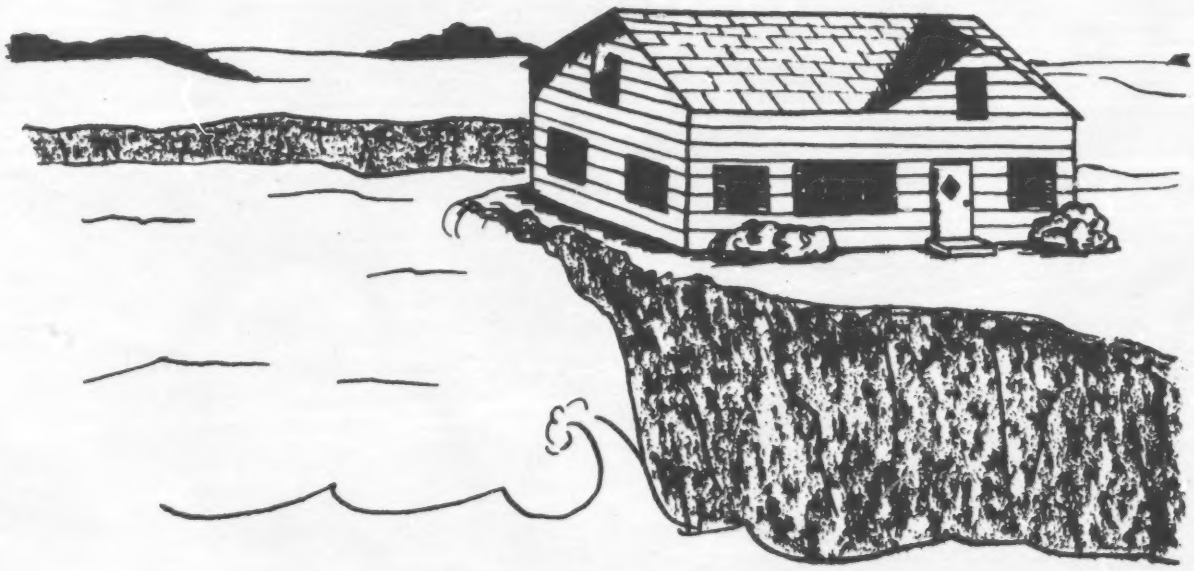

Ohio Sea Grant Program
Charles E. Herdendorf, Program Director
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TEACHER GUIDE

OEAGLS INVESTIGATION #6

Completed April, 1979
Revised July, 1980

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The two Painesville-on-the-Lake photos are from the Ohio Department of Transportation.

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OVERVIEW

Students study a section of the Lake Erie coast from aerial photographs. They determine the recession rate of two different sections of the coast, one upstream and one downstream from several groins. They learn about the processes of erosion and deposition along a shore and how groins affect these processes.

PREREQUISITE STUDENT BACKGROUND

Students should be able to read topographic maps, use scale, and understand the origin of longshore currents.

OBJECTIVES

When students have completed this activity they should be able to:

1. Recognize some shoreline features on air photos.
2. Use air photos to:
   a. determine how much shoreline has eroded away in a given area.
   b. estimate an average rate of recession for a section of shoreline.
3. Calculate the amount of material eroded from a portion of shoreline.
4. Predict the effect of groins on a shoreline.

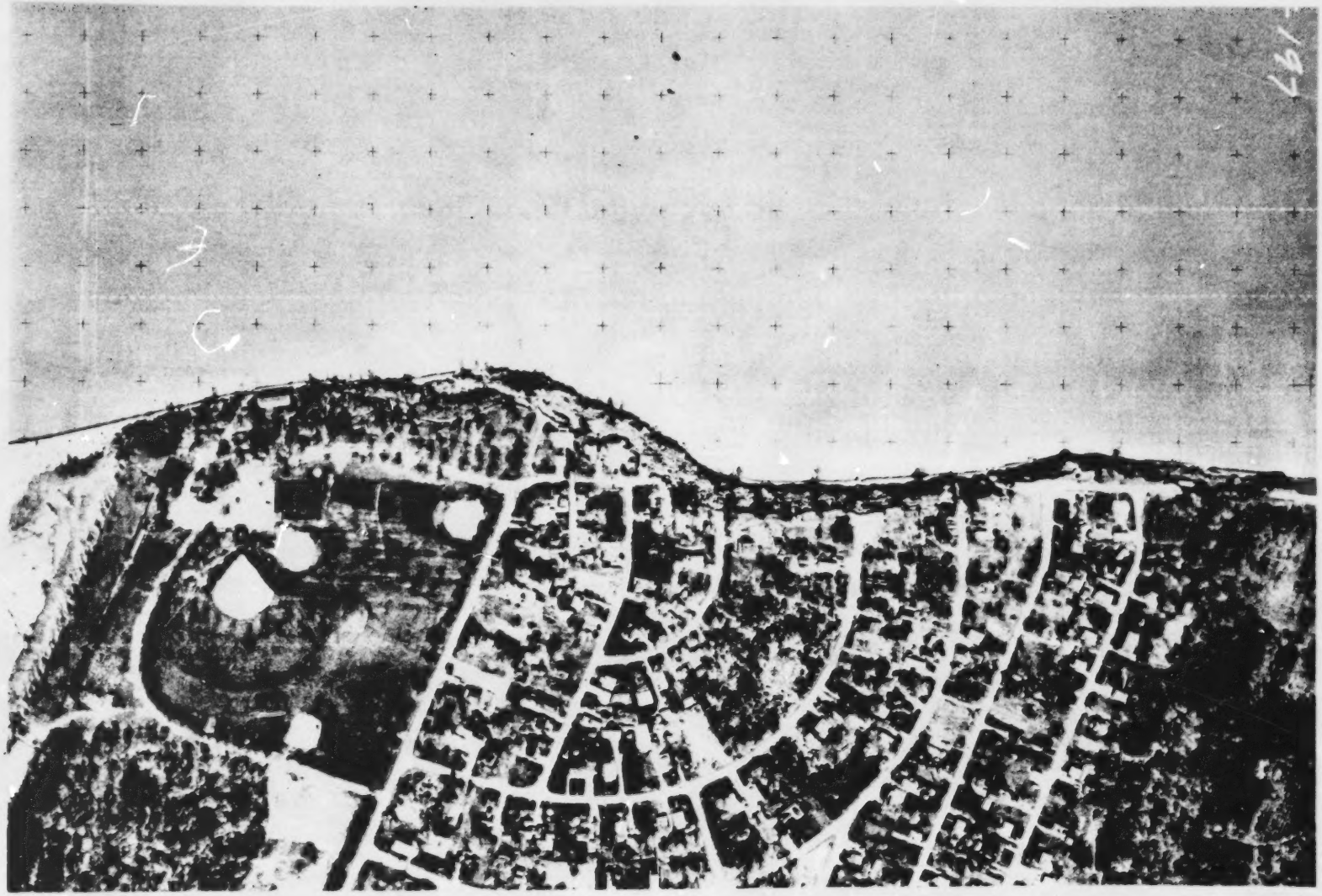
MATERIALS

Each pair of students will need the following materials:

1. Tracing paper, pencil, paper clips and colored pencils.
2. A set of two aerial photographs of the Painesville Township Park. They can be purchased from the Ohio Department of Transportation, Motor Transport-Central Garage, 1620 West Broad Street, Columbus, Ohio 43223. In 1978 they were available for a little over $1.00 each when purchased in quantities of 15. You will need the 1973 Painesville Township Park (No. 5196-5-197) and the 1954 Painesville Township (No. 497-3-43).
3. Graph paper, 10 squares per inch.
4. A copy of the Perry, Ohio, quadrangle. These are available from The Ohio Division of the Geological Survey, Ohio Department of Natural Resources, Fountain Square, Columbus, Ohio 43224. In 1978, they cost $1.25 each.

16

Painesville-on-the-Lake, 1954



Painesville-on-the-Lake, 1973

SUGGESTED APPROACH

You might introduce the investigation by using the film, The Beach: A River of Sand, from the AGI Earth Science Series, available through Encyclopedia Britannica Films, Inc. 425 North Michigan Avenue, Chicago, IL 60611. The film effectively illustrates the development and effects of longshore currents on shorelines, and some of the problems created by harbors and other features that interrupt the littoral drift.

For those schools along the lake, a field trip would be an effective follow-up to the investigation. Carter, 1973 describes locations along the lake where the effect of erosion processes can be observed.

ACTIVITY A

Keywords: groin, bluff, shoreline.

PROCEDURE

Be certain that students have their photos oriented properly before they begin the activity.

1. Students should observe the groins at the center of the photo, the sand beaches to the west and the slumping bluffs to the east of the groins.

2. In the second photo, the beach has largely disappeared and the bluffs have retreated southward. A part of the highway has been removed as well as serveral buildings.

3. There are six rather prominent groins. In the 1954 photo, students may see several other small structures built out from the beach. These may be small groins or perhaps piers. Of the three largest groins, one has become very faint in the 1973 photo. Other groins seem to have disappeared. They have been submerged by the higher lake level. The general level of the lake increased over the decade from 1960 to when this last photo was taken. This is the major reason that the beach is not as wide and that the groins seem less prominent.

4. The base of the bluff is used as an indicator of the position of the shoreline. The beach itself varies considerably in size because of normal processes such as longshore currents and periodic changes in lake level. It, therefore, is not a good indicator of the position of the shoreline.

5-9. See Appendix A. The scales of the two photos are not

exactly the same. Therefore, students will not be able to get a perfect match on road intersections. But they can match close enough to get a good idea of the changes that have occurred to the shoreline.

10-11. See Appendix A.

12. The two shorelines are the result of erosional processes and the consequent retreat of the shoreline to the south. One caution: line A will cross a gravel pit. On the 1973 photo, gravel has been removed to the beach. Therefore, there is a broad white stretch on the photo. Students will interpret this as cliff recession.

13. The shaded area represents land removed by erosion.

14. A greater amount of erosion has taken place to the east. Because of the presence of the gravel pit, students may not arrive at this conclusion. You should discuss this with them.

15. The groins protected the portion of the shoreline they were connected to. The new beaches, once formed, provide a place for waves to expend their energy. This energy is not used to erode the upland areas; consequently, the recession rate of the shoreline is considerably reduced.

16. Groins will cause deposition on their upcurrent side, and increased erosion on the downcurrent side. Therefore, it appears that the predominant direction of the longshore currents is from west to east.

ACTIVITY B

Keywords: recession rate

1-3. See Appendix B, completed worksheet. In his investigation of shoreline recession rates, Carter (1976) used the top of the bluff line, which gives you a more accurate idea of the recession rate. In this activity, however, the base of the bluff is much easier to see on the aerial photographs, so should be used instead.

4. The eastern part has the higher recession rate. This means that the bluffs retreat southward more rapidly in this area. The best place to own shoreline property would be behind the groins because that is where the recession rate is the least. Again students might not get the expected results because of the presence of the gravel pit (refer to #12 in Part A).

5. Students will have to use their judgement in counting the squares. It is easiest if they align the shoreline with a line of the graph paper.

6-7. See Appendix B.

8. When this map was revised (1970) the approximate mean Lake elevation was 571 feet.

9. To the west of Hardy Road, the contour lines at the top of the bluff are very confusing. However, it appears that the elevation of the top of the bluff is 610 or 620 feet. The answers your students give on lines V and W will vary according to the elevation that they select for the bluffs.

10. The elevation is 600 feet.

11-12. See Appendix B.

REVIEW QUESTIONS

1. Procedures similar to those used in this investigation could be used to determine recession rate of a section of seacoast. The average distance between two successive shorelines can be determined. Their average distance is to be divided by the number of years between the time the photos were taken. The result is the recession rate.

2. To determine the volume of material lost, the area between the two shorelines is first determined. Then the height of any bluffs or cliffs is determined from a map. Multiplying the area by the average height of cliffs will give approximately the volume of material removed.

3. A groin will cause deposition on the upstream side, thereby protecting that part of the shoreline from erosion. On the downstream side, however, the longshore currents having lost their load of sand to the groin will pick up a new load, thereby removing some or all of the beach and exposing this portion of the shoreline to intense erosion.

BACKGROUND INFORMATION

The techniques used in this activity to determine the rate of recession and the amount of materials lost through beach processes are adapted from the techniques used by professional geologists. A study of the Lake Erie coastline (Carter, 1976) documents recession rates and the effects of groins and other structures in several areas of Lake County. Information from this report would provide interesting supplemental information for your students.

Another publication by Carter (1973) was developed for a field trip along the Lake Erie coast. It illustrates with aerial photos many erosion problems starting at Maumee Bay, outside of Toledo and ending at Painesville, the location of this activity. This would be an excellent source for field trips taken in conjunction with this activity. You would be able to make comparisons of your own area of the shore with the Painesville area.

Painesville-on-the-Lake is located along the shore of the eastern basin of Lake Erie. Here the prevailing southwesterly winds have a fetch (long unrestricted distance) over the lake and, therefore, cause longshore currents that have a net easterly movement. In the western part of the Lake Erie Basin, however, such as in the area of Sandusky, these winds at the shore blow only from over the land, and there is little if any fetch. The occasional northeasterly storms, then, are the major cause of longshore currents especially because of the long fetch that they have over the lake. As a result, the net movement of longshore currents on the southern shore in the western basin is in a westerly direction.

REFERENCES

Charles H. Carter, 1976, Lake Erie Shore Erosion, Lake County, Ohio: Setting, Processes, and Recession Rates from 1876-1973, Report of Investigations No. 99, Division of Geological Survey, Department of Natural Resources, State of Ohio, Columbus, Ohio 43224.

_____, 1973. Natural and Manmade Features Affecting the Ohio Shore of Lake Erie, Guidebook No. 1, Division of Geological Survey, same address as above.

North Central Division, Corps of Engineers, Department of Army, Help Yourself. This is a free brochure describing problems and solutions of shoreline erosion. Copies can be obtained from the District Engineer, U.S. Army Engineer District, 219 South Dearborn Street, Chicago, Illinois 60604.

EVALUATION ITEMS

1. An important factor determining the rate of erosion occurring along the shore of Lake Erie is

   1. differences in the height of the bluffs.
   *2. the rock materials making up the bluffs.
   3. differences in climate along the lake.
   4. the amount of boat traffic in different parts of the lake.

2. Erosion along the shore of the lake is caused by

   1. wind blowing across the beaches and bluffs.
   2. freezing and thawing of material that makes up the shoreline.
   *3. waves and currents.
   4. man-built structures along the lake.

3. Over the past 20 to 25 years the southern shore of Lake Erie has
   *1. moved southward.
   2. remained in about the same place.
   3. moved northward filling in a section of the lake.
   4. been built up by waves throwing material onto the bluffs.

4. Groins are structures built to

   *1. trap beach sand.
   2. protect the shore from wind.
   3. provide recreational beaches.
   4. carry sewage out into the lake.

5. To calculate the recession rate of the shoreline you must know

   1. the height of the bluffs.
   *2. the distance the shoreline has moved.
   3. the depth of water.
   4. the amount of wave and current action that has affected the shore.

6. To determine the amount of material that has been removed from a shoreline over a particular period of time you must know the area of surface that has been removed and the

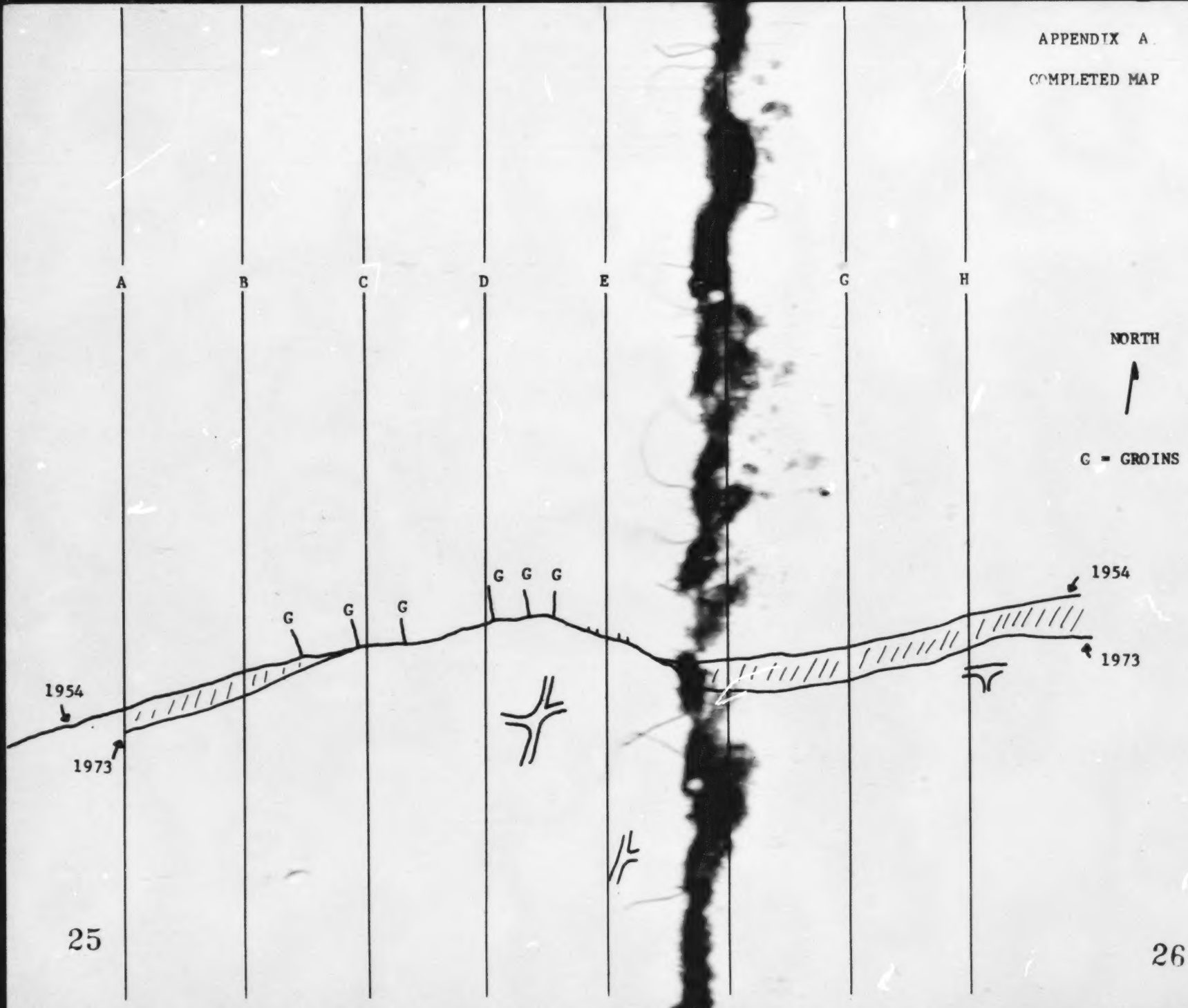
   1. type of material that makes up the bluffs.
   *2. average height of the bluffs.
   3. amount of wave and current action that has occurred to the shore.
   4. depth of the water.

7. When determining recession rate the shoreline is taken as the

   1. place where the water of the lake meets the beach.
   2. top of the bluffs.
   *3. place where the beach meets the bluffs.
   4. place where the waves just begin to break.

APPENDIX A

COMPLETED MAP



Appendix B: Completed Worksheet

LINE	WEST A B C D	EAST E F G H
Q	90ft + 75ft + 0 + 0 = 165ft	0 + 100ft + 120ft = 325ft
R	41.25 ft	81.25 ft
S Recession Rate R ÷ 19 yr	2.2 ft/yr	4.3 ft/yr
T Squares	25	90
U Surface area T x 160 sq ft	4,000 sq ft	14,400 sq ft
V Cliff height	40 or 50 ft	30 ft
W Volume U x V	160,000 ft^3	432,000 ft^3
X Yearly loss W ÷ 19 yr	8,421 ft^3/yr	22,737 ft^3/yr